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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

# Some Factors Affecting Germination of Fourwing Saltbush

by

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Because of many desirable characteristics, fourwing saltbush (Atriplex canescens) is one of the most valuable browse plants on Southwestern ranges. Studies of native stands indicate this species grows under a wide variety of environmental conditions, withstands drought, heat, and cold, and provides palatable, nutritious forage the year round for both game and livestock. More than 40 years ago, animal husbandmen recognized the importance of fourwing saltbush as forage for range cattle, and advocated increasing it on New Mexico range. But they admitted their attempts to establish stands artificially were largely unsuccessful (Foster, et al. 1921).

Through the years, fourwing saltbush has been seeded numerous times by ranchers and public agencies; some succeeded, but most of them failed. We cannot explain the failures until more is learned about the factors governing successful establishment. More information is needed on how germination and establishment are affected by source of seed, age of seed, conditions of seed storage, depth and time of seeding, soil moisture and temperature, insects, diseases, rodents, rabbits, and other factors.

This report presents preliminary information on the effects of differences in source of seed, treatment of seed, and temperatures on germination of fourwing saltbush seed in the laboratory. Several of the findings appear to have application value for range seedings.

## LITERATURE REVIEW

A number of exploratory studies were conducted from 1924 to 1928 near Las Cruces, New Mexico, with fourwing saltbush seed collected locally (Wilson 1928). Germination tested at 68° to 86°F. ranged from 0 to 36 percent for 11 lots of seed; percentage germination decreased little if any until the seed was at least 6 or 7 years old. Based on other studies conducted from 1936 to 1941 on the College Ranch north of Las Cruces, N. M., Bridges (1941) concluded that, in spite of numerous failures, reseeding with fourwing saltbush will eventually be successful. Of 26 seeding trials, the seed failed to germinate in 11, and while some germination took place in 15 trials, only 1 gave a good stand. He attributed the failures to rabbit depredation, poor seedbed preparation, and seeding at the wrong time of year.

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The Woody Plant Seed Manual (U. S. Forest Serv., 1948) reports fourwing saltbush seed exhibit variable dormancy. Some lots germinate promptly without any pretreatment; others germinate over a period of 1 or 2 years after sowing in nursery beds. In one series of tests, stratification at 41°F. did not improve germination. The Manual lists the following information:

| | Seeds per pound (Number) | Germination (Percent) |
|---|---|---|
| Low | 10,500 | 4 |
| Average | 22,500 | 18 |
| High | 40,000 | 47 |

Recommendations were to conduct germination tests in sand flats at 50°F. (night) to 77°F. (day) for 20 to 30 days.

Detailed studies by Hervey[2] with fourwing saltbush seed collected near Delta, Colorado, showed removal of the wings by hammermilling improved the ease of handling, but did not affect germination. Fewer seeds stored in sealed containers at 37° to 41°F. germinated than seeds stored open or in sealed containers at room temperatures for 3 years (19 percent, compared with 21 and 24 percent). Vermiculite proved a good medium for germination tests in petri dishes because results were close to those obtained in the nursery. Treating seed with fungicides did not affect germination percentages. Temperature had no influence on germination until it dropped below 59°F. Germination was 47 percent at 68°F., 45 percent at 59°F., and 7 percent at 39°F.

Inhibitors in the seed coat and bracts may be responsible for the generally low germination percentages. Germination of other species of Atriplex in Australia was found to be inhibited by substances diffusing from the fruit bracts, and the inhibitor was classed as a chloride (Beadle 1952). Koller's studies with an annual Atriplex in Israel (1957) indicated the presence of a water-soluble inhibitor that in nature is leached from the fruit bracts by rain water. Other studies in California showed enough saponin in the bracts of fourwing saltbush to reduce germination (Nord and Van Atta 1960).

Twitchell (1955) found that soaking saltbush seed in water for several hours removed more than 90 percent of the chloride present and increased germination. Drying the seed for 7 days before planting gave higher germination than planting the wet seed. Other similar studies by Nord and Whitacre (1957) showed that 4 hours of soaking followed by 8 days of drying did not affect germination in the laboratory, but size of seed and degree of scarification had significant effects on germination. The smallest seeds averaged 54 percent germination, against 33 percent for the large seeds. Heavy scarification increased germination substantially: 42 percent compared to 31 percent for negligible and moderate scarification.

## PROCEDURES

Two separate tests were conducted. Seeds used in the tests were collected at different sites in Arizona and New Mexico in 1961 (table 1). All seeds were stored in a warehouse from date of collection until the studies began. Temperature in the warehouse, regulated by thermostatic controls, ranged from 55° to 65°F. in winter to 75° to 80°F. in summer.

Seeds from Isleta, Mountainair, and Corona were used in the first test. On November 18, 1962, half the seeds of each lot were soaked for 8 hours in tap water, rinsed, then dried. Each of these lots was subdivided. Wings were removed from half the seeds by hand-rubbing them over a 7/64-inch screen. Care was taken not to scarify the seed coat while removing the wings. Through further subdivision, a portion of the seed from the four differently treated lots was stored under each of three conditions: (1) dry storage at 55°F., (2) dry storage in cloth bags at 39°F., and (3) mixed with wet vermiculite, put in wax cartons, and stored at 53°F.

The seeds were examined January 10, 1963, after 52 days of storage. None of the seeds

[2] *Hervey, Donald F. Factors which influence the reseeding of certain browse species in Colorado. 1955. (Unpublished doctoral dissertation on file at School of Forestry, Agricultural and Mechanical College of Texas, College Station, Texas.)*

Table 1.--Description of eight sites in Arizona and New Mexico where fourwing saltbush seeds were collected in 1961, and the number of seeds per pound

| Seed source | Identification No. | Characteristics of collection site | | | Date seed collected | Seeds per pound | |
|---|---|---|---|---|---|---|---|
| | | Geographic location | Elevation | Annual precipitation | | Winged | De-winged |
| | | | Feet | Inches | | Number | |
| NEW MEXICO: | | | | | | | |
| Isleta | A-27 | 1 mi. E. of Isleta | 5,000 | 9 | Oct. | 18,000 | 29,200 |
| Mountainair | A-43 | 5 mi. S. of Mountainair | 6,700 | 14 | Oct. | 19,100 | 38,100 |
| Corona | A-48 | 6 mi. W. of Corona | 6,300 | 15 | Oct. | 25,300 | 38,800 |
| Monica | A-79 | 20 mi. W. of Magdalena | 6,600 | 13 | Nov. | 14,800 | 27,900 |
| Glenwood | A-94 | 3 mi. S. of Glenwood | 4,500 | 14 | Oct. | 28,900 | 51,300 |
| ARIZONA: | | | | | | | |
| Flagstaff | A-85 | 18 mi. NW. of San Francisco Peaks | 6,500 | 17 | Dec. | 34,000 | 58,100 |
| Beaver Creek | A-86 | 3 mi. SE. of Camp Verde | 3,500 | 14 | Dec. | 26,600 | 53,800 |
| Chevelon | A-78 | 30 mi. S. of Winslow | 6,200 | 15 | Nov. | 17,500 | 31,100 |

stored dry at 55° or 39°F. had germinated, but more than 50 percent of the seed stored wet at 53°F. germinated and could not be used for further tests.

The germination tests of Isleta, Mountainair, and Corona seed were begun January 11 in petri dishes with wet vermiculite as the substrate. Twenty-five seeds were put in each dish. Three germination temperatures were compared: 73°F., 54°F., and 39°F. The dishes were arranged in a factorial design which provided four replicates of every treatment applied to each seed source. Germinated seeds were counted at 2-day intervals for 28 days.

All eight sources of seed listed in table 1 were included in the second test. Procedures were the same as in the first test except that none of the seed was soaked. Half of the seeds in each lot were de-winged before the germination test was begun February 8. Three temperatures were compared: 77°F., 58°F., and 42°F. Germinated seeds were counted every day for 36 days.

## RESULTS

### First Test--Three Seed Sources

Seed collected near Isleta and Mountainair germinated better than seed from Corona:

| | Germination after 28 days (Percent) |
|---|---|
| Isleta | 49.9 |
| Mountainair | 44.0 |
| Corona | 16.5 |

Soaking the seed for 8 hours to remove chlorides or other inhibitors had no effect on germination (table 2). Isleta seed tended to germinate better when not soaked, but the average responses of all three sources showed no significant difference in germination between soaked and unsoaked seed.

Germination was significantly higher at an average temperature of 54°F. than at 73°F.

Table 2.--Comparison of fourwing saltbush seeds soaked in water for 8 hours and those not soaked, as shown by percentage germination; seeds from three collection sites in New Mexico

| Storage temperature | Average germination temperature | Seed treatment | Seed sources: Isleta | Mountainair | Corona | Average |
|---|---|---|---|---|---|---|
| | | | - - - - Percent germination - - - - | | | |
| 55° F. | 73.3° F. | Soaked | 24 | 43 | 9 | 25.3 |
| | | Not soaked | 52 | 38 | 8 | 32.7 |
| | 54.5° F. | Soaked | 66 | 58 | 42 | 55.3 |
| | | Not soaked | 70 | 60 | 18 | 49.3 |
| 39° F. | 73.3° F. | Soaked | 33 | 40 | 11 | 28.0 |
| | | Not soaked | 54 | 27 | 11 | 30.7 |
| | 38.9° F. | Soaked | 0 | 0 | 0 | 0 |
| | | Not soaked | 0 | 0 | 0 | 0 |

All three sources of seed germinated better at the lower temperature. No seeds germinated at 39°F.

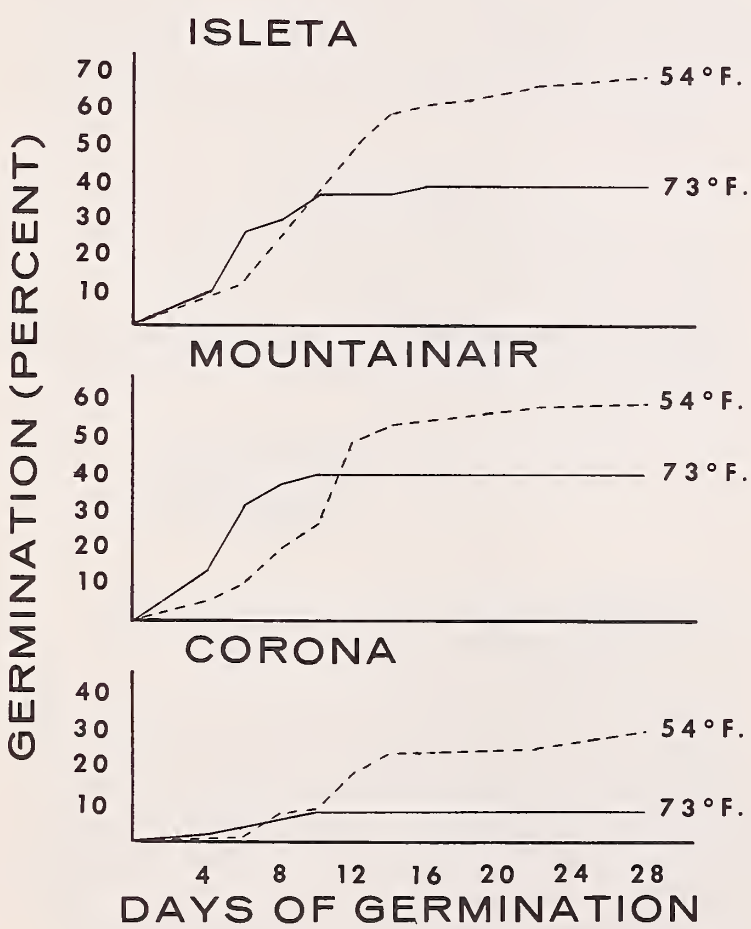


*Figure 1.--Germination rates of fourwing saltbush seed at 54° F. and 73° F. during a 28-day test period.*

Germination began faster at 73°F. than at 54°F. (fig. 1). On the sixth day, for example, about twice as many seeds had germinated at the higher temperature. By the tenth day, however, germination had stopped at 73°F., but was rapid at 54°F. Rate of germination continued to be rapid at 54°F. until the fourteenth day.

None of the seeds stored dry at 39°F. for 52 days, then put in petri dishes with wet vermiculite for 28 days at 39°F., germinated. Apparently the seed remained dormant for the entire 80 days at this relatively low temperature.

De-winging the seed did not affect the final germination percentages (table 3). Winged and de-winged seed germinated about the same regardless of seed source or germination temperature, although the de-winged seed germinated more quickly than the winged seed (fig. 2). This was most pronounced for seed germinated at 54°F., where germination of de-winged seeds remained higher than winged seeds for 26 days. In contrast, at 73°F. the winged seed equaled the de-winged seed in germination by about the tenth day.

## Second Test--Eight Seed Sources

Germination varied considerably according to source of seed and germination temperature. Isleta seed germinated better than seed from

Table 3.--Comparison of winged and de-winged fourwing saltbush seeds as shown by percentage germination at end of 28 days; seeds from three collection sites in New Mexico

| Storage temperature | Average germination temperature | Seed treatment | Seed sources | | | |
|---|---|---|---|---|---|---|
| | | | Isleta | Mountainair | Corona | Average |
| | | | - - - - Percent germination - - - - | | | |
| 55° F. | 73.3° F. | Winged | 33 | 49 | 10 | 30.7 |
| | | De-winged | 43 | 32 | 7 | 27.3 |
| | 54.5° F. | Winged | 60 | 64 | 34 | 52.7 |
| | | De-winged | 76 | 54 | 26 | 52.0 |
| 39° F. | 73.3° F. | Winged | 53 | 32 | 5 | 30.0 |
| | | De-winged | 34 | 36 | 17 | 29.0 |
| | 38.9° F. | Winged | 0 | 0 | 0 | 0 |
| | | De-winged | 0 | 0 | 0 | 0 |

any of the other seven sources. Based on average germination for all treatments included in the 36-day test, the different sources could be grouped as follows:

| | Percent |
|---|---|
| High germination: | |
| Isleta | 74.3 |
| Medium germination: | |
| Mountainair | 45.7 |
| Flagstaff | 42.3 |
| Corona | 36.7 |
| Low germination: | |
| Chevelon | 29.3 |
| Glenwood | 27.3 |
| Monica | 26.3 |
| Beaver Creek | 26.3 |

The germination percentages showed no apparent relationship with elevation, annual precipitation, or latitude of the collection site, or with size of seed (number of seeds per pound).

Germination was significantly higher at average temperatures of 58°F. or 42°F. than at 77°F. (fig. 3). For all sources of seed tested, germination was substantially less at the highest temperature. Improvement in percent germination at 58°F. compared with 77°F. was especially pronounced for the Corona, Glenwood, Flagstaff, and Beaver Creek seed. Though there was a trend toward higher germi-

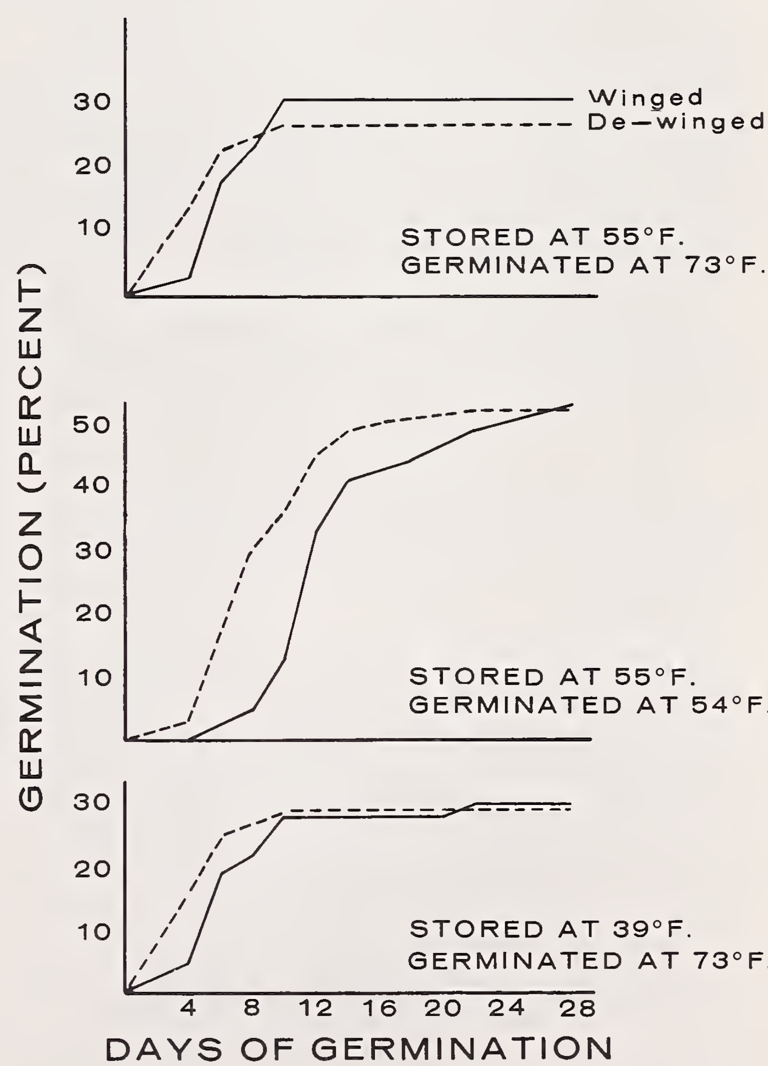


*Figure 2.--Germination rates for winged and de-winged fourwing saltbush seed during a 28-day test period.*

nation at 58°F. than at 42°F., the difference between average percent germination under these two temperatures was not significant statistically.

Rate of germination varied with temperature (fig. 4). At 77°F., germination was rapid from the fourth to the tenth day, then practically stopped. At 58°F., germination was slow until the tenth day, then became extremely rapid. This rapid rate continued for 4 days, after which germination took place more gradually for 14 days, then stopped. At 42°F., no germination was observed until the sixteenth day; the rate was moderately fast from the eighteenth to the thirty-fourth day, and appeared to have stopped by the thirty-sixth day. A final check showed no germination on the thirty-eighth day.

De-winging the seed did not affect final germination in the second test. Average germination percentages indicate a slight benefit from de-winging, but the differences are not significant (table 4). Of eight sources of seed, only the Monica seed showed consistently higher germination for de-winged seed under all three temperature conditions.

The de-winged seed germinated more quickly (fig. 5); under temperatures of 77°F. and 58°F., more than twice as many de-winged as winged seed had germinated by the sixth day. But by the tenth day at 77°F. and by the twenty-fourth day at 58°F., germination of the winged seed practically equaled that of the de-winged seed.

Results of the second test generally were in accord with those of the first test. Germination percentages of the three sources of seed used in both tests, however, showed large variability (tables 3 and 4). Results of the two tests for winged seed germinated at the middle temperature illustrate this variability:

| Seed source | First test: 54°F. | Second test: 58°F. |
|---|---|---|
| | (Percent germination) | |
| Isleta | 60 | 92 |
| Mountainair | 64 | 48 |
| Corona | 34 | 40 |

The reasons for these rather large differences in germination between the two tests are not

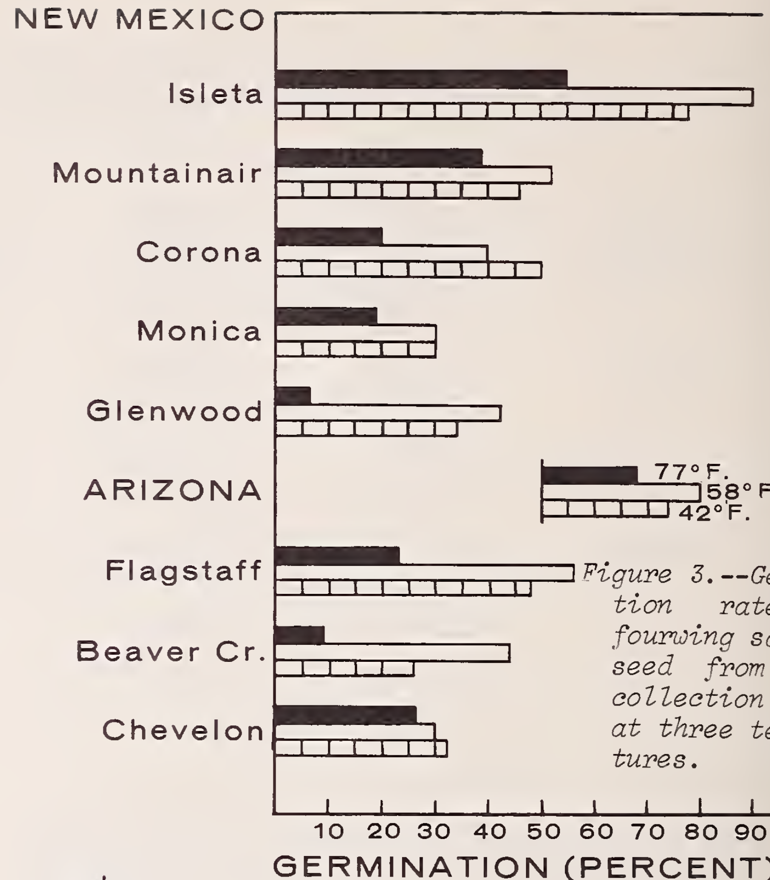


*Figure 3.--Germination rates of fourwing saltbush seed from eight collection sites, at three temperatures.*

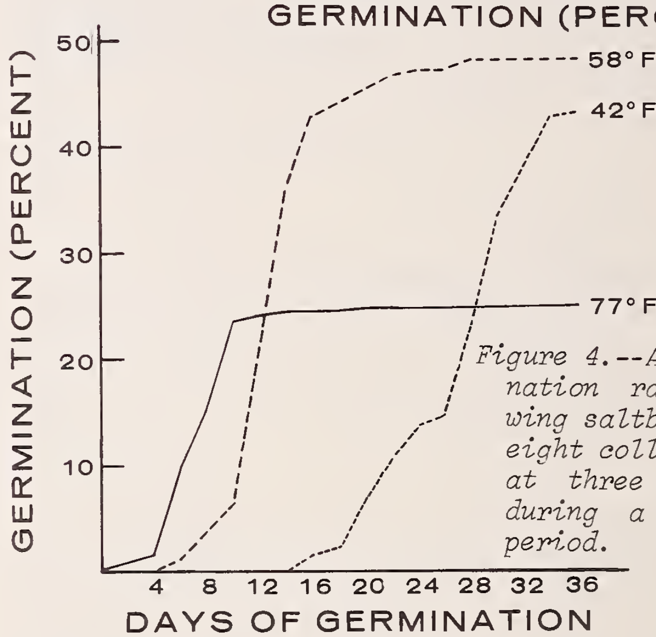


*Figure 4.--Average germination rate of fourwing saltbush seed from eight collection sites, at three temperatures, during a 36-day test period.*

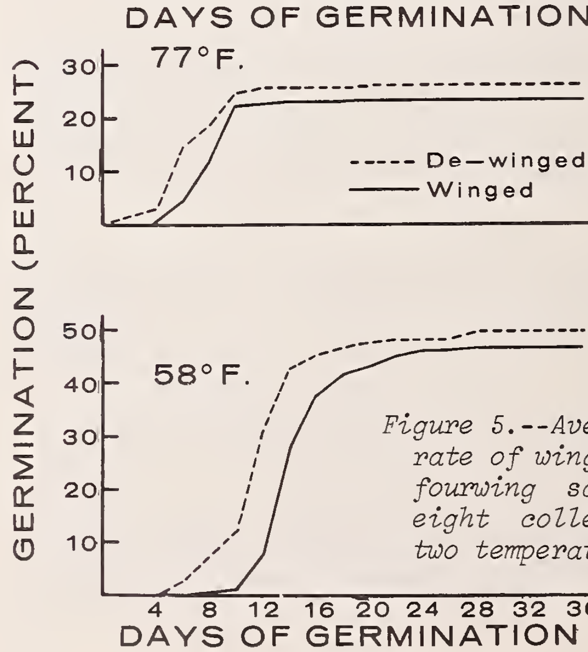


*Figure 5.--Average germination rate of winged and de-winged fourwing saltbush seed from eight collection sites, at two temperatures.*

Table 4. --Comparison of winged and de-winged fourwing saltbush seeds at three germination temperatures as shown by percentage germination at end of 36 days; seeds from eight collection sites in New Mexico and Arizona

| Germination temperature | Seed treatment | New Mexico | | | | | Arizona | | | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Isleta | Mountainair | Corona | Monica | Glenwood | Flagstaff | Beaver Creek | Chevelon | |
| | | Percent germination | | | | | | | | |
| 76.6° F. | Winged | 60 | 36 | 14 | 12 | 10 | 26 | 6 | 22 | 23.3 |
| | De-winged | 50 | 42 | 26 | 26 | 2 | 20 | 12 | 30 | 26.0 |
| 57.6° F. | Winged | 92 | 48 | 40 | 12 | 40 | 48 | 48 | 44 | 46.5 |
| | De-winged | 88 | 56 | 40 | 48 | 44 | 64 | 40 | 16 | 49.5 |
| 41.8° F. | Winged | 76 | 60 | 44 | 24 | 32 | 44 | 28 | 32 | 42.5 |
| | De-winged | 80 | 32 | 56 | 36 | 36 | 52 | 24 | 32 | 43.5 |

readily explained. Large variability among seeds in the different sample lots probably was a factor, but induced dormancy of the embryos caused by inadvertent exposure to high or low temperatures, or other conditions, may also have been a factor.

Cutting tests.--In an attempt to explain some of the germination results, cutting tests were conducted on small samples of seed. From 50 to 200 individual seeds of each source were checked to see if they were filled.

Individual seeds were cut in half and examined with a hand lens to determine the presence of an embryo and endosperm. Results of this examination were as follows:

| Seed source | Number of seeds filled (Percent) | All seed (Percent germination) | Filled seeds only (Percent germination) |
|---|---|---|---|
| Isleta | 93 | 74 | 80 |
| Mountainair | 63 | 46 | 73 |
| Corona | 68 | 37 | 54 |
| Monica | 49 | 26 | 54 |
| Glenwood | 80 | 27 | 34 |
| Flagstaff | 65 | 42 | 64 |
| Beaver Creek | 61 | 26 | 43 |
| Chevelon | 60 | 29 | 48 |

The differences in number of seeds filled partially explain some of the germination results. For example, only about half of the Monica seed was filled, which accounts in part for the relatively low average 26 percent germination of this source. By contrast, the seed from Flagstaff which was 65 percent filled gave 42 percent germination, and the Isleta seed, 93 percent filled, gave 74 percent germination.

The percentage of seed filled does not fully explain the germination results, however. Embryo dormancy or other characteristics of the seed apparently influenced their germination. Examples are the Beaver Creek seed which was 61 percent filled yet only 43 percent of the filled seed germinated, and the Glenwood seed which was 80 percent filled but only 34 percent of these filled seed germinated.

## DISCUSSION

These tests showed germination of fourwing saltbush varied with source of seed. In a comparison of eight sources, seed collected at Isleta, New Mexico, showed significantly higher germination than seed from other sources. Three sources of seed were intermediate, while the remaining four sources were low in germination. Part of the variation in germination among sources can be explained by differences in the number of seeds that were filled, or contained embryos. The number of seed with embryos probably was determined by some environmental factors during pollination and seed maturation, such as temperature, moisture, or wind. The embryos in seeds from some sources exhibited a greater dormancy than seed from others, also. It is obvious, therefore, that when collecting wild seed of fourwinged saltbush, seed source is an important consideration. Further research is needed, however, to determine whether geographical

source or environmental conditions should be the main consideration in deciding where and when to collect seed.

Removing the wings from the seed did not improve the total germination of fourwing saltbush. The de-winged seed, however, germinated more quickly than the winged seed. This faster germination is desirable because the right combination of temperature and soil moisture is of short duration in many range areas. Other advantages of de-winging the seed are: (1) ease of handling, especially when the seed is to be drilled, (2) reduction in bulk, and (3) easier coverage with soil. Soaking fourwing saltbush seed to remove chlorides or other suspected inhibitors does not seem necessary.

Temperature strongly influenced germination of fourwing saltbush. Germination of seed from all eight sources was higher at temperatures from $42^{o}$ to $58^{o}$F. than at temperatures of $73^{o}$ to $77^{o}$F. Rates of germination were lower at the lower temperatures, but these lower rates could be a benefit. The developing seedling might undergo a hardening process that would make it less susceptible to frost damage. Additional studies are needed to define more clearly the optimum temperatures for germination, but indications from this study were that the optimum temperatures may vary with source of the seed.

Until additional information is obtained concerning temperature effects on germination of fourwing saltbush seed, the findings from these tests might be used as preliminary guides. They indicate that germination is better within the range of $40^{o}$ to $60^{o}$F. than at temperatures of $70^{o}$F. or higher. For most range areas in the Southwest, temperatures of $40^{o}$ to $60^{o}$F. correspond with the spring and fall seasons, whereas temperatures above $70^{o}$F. correspond with the summer season. This suggests fourwing saltbush should be seeded in the spring or fall, as temperatures probably would be too high during the summer, especially at the lower elevations. Although the summer months appear unfavorable from the standpoint of temperatures, these months are best when considering dependability and amount of precipitation in the Southwest. Because of the apparent conflict between temperature and moisture factors, further research is needed to determine the right time to seed. Perhaps other unknown factors affect germination. But results of the tests discussed here suggest that temperature may be equally as important as moisture in governing the germination of fourwing saltbush.

## LITERATURE CITED


Beadle, N. C. W.
1952. Studies on halophytes. I. The germination of the seeds and establishment of the seedlings of five species of Atriplex in Australia. Ecology 33: 49-62.

Bridges, J. O.
1941. Reseeding trials on arid rangeland. N. Mex. Agr. Expt. Sta. Bul. 278, 48 pp., illus.

Foster, Luther, Lantow, J.L., and Wilson, C.P.
1921. Chamiza as an emergency feed for range cattle. N. Mex. Agr. Expt. Sta. Bul. 125, 29 pp., illus.

Koller, Dov.
1957. Germination-regulating mechanisms in some desert seeds, IV. Atriplex dimorphostegia Kar. et Kir. Ecology 38: 1-13, illus.

Nord, Eamor C., and Van Atta, George R.
1960. Saponin--a seed germination inhibitor. Forest Sci. 6: 350-353.

________ and Whitacre, James E.
1957. Germination of fourwing saltbush seed improved by scarification and grading. *Calif. Forest and Range Expt. Sta. Res. Note 125, 5 pp.

Twitchell, La Forrest T.
1955. Germination of fourwing saltbush as affected by soaking and chloride removal. Jour. Range Mangt. 8:218-220, illus.

U. S. Forest Service.
1948. Woody plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus.

Wilson, C. P.
1928. Factors affecting the germination and growth of chamiza (Atriplex canescens). N. Mex. Agr. Expt. Sta. Bul. 169, 29 pp., illus.


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